

SELECTIVE SHIELD/MATERIAL FLOW MECHANISM

Background Of The Invention

5       This invention generally relates to electroplating and  
electroless plating apparatus and methods.

10       Electroplating is a common process for depositing a thin  
film of metal or alloy on a substrate such as, for example,  
a variety of electronic components and semiconductor chips.  
In a typical electroplating apparatus or system, the  
substrate is placed in a suitable electrolyte bath  
containing ions of a metal to be deposited. The substrate  
is connected to the negative terminal of a power supply to  
15       form a cathode, and a suitable anode is connected to the  
positive terminal of the power supply. Electrical current  
flows between the anode and cathode through the electrolyte  
and metal is deposited on the substrate by an  
electrochemical reaction.

20       In many electronic components, it is desirable to deposit  
the metal film with a uniform thickness across the substrate  
and with uniformity of composition. However, the  
electroplating process is relatively complex, and various  
25       naturally occurring forces may adversely affect the  
electroplating process. Most significantly, the electrical  
current or flux path between the anode and the cathode may

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spread or curve, making it difficult to achieve uniform electrodeposition.

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#### Summary Of The Invention

An object of this invention is to provide an improved electroplating apparatus and method.

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Another object of the present invention is to selectively and controllably adjust the amount of electric flux passing towards selected areas of a workpiece, during an electroplating process, in order to deposit a metal film or alloy with a uniform thickness across the workpiece. This apparatus could also be used to regulate solution flow in an electroless plating deposition bath which would in turn make the bath more capable of depositing in small through holes.

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A further object of this invention is to use a unique anode shield/material flow apparatus that can be controllably adjusted on the fly, during an electroplating process, to selectively isolate areas of the workpiece.

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Another object of this invention is provide an infinitely adjustable mechanism that can selectively isolate areas to be electroplated.

These and other objectives are attained with an apparatus and method for electroplating a workpiece. The apparatus comprises, generally, an anode, a cathode, and a selective shield/material flow assembly. In use, both the anode and the cathode are immersed in a solution, and the cathode is used to support the workpiece. During an electroplating process, the anode and the cathode generate an electric field emanating from the anode towards the cathode, to generate a corresponding current to deposit an electroplating material on the workpiece.

The selective shield/material flow assembly is located between the anode and the cathode, and forms a multitude of adjustable openings. These openings have sizes that are adjustable during the electroplating process for selectively and controllably adjusting the amount of electric flux passing through the selective shield/material flow assembly and the distribution of the electroplating material on the workpiece.

With a preferred embodiment of the invention, described in detail below, the selective shield/material flow assembly is used to selectively isolate an area of the workpiece from plating by use of an individual adjustable selective shield/material flow mechanism. The selective flow material flow assembly can comprise one or more selective shield material flow mechanisms. The selective shield material flow assembly can be adjusted selectively on one, two, or

multi axes. In another embodiment, the shielding, in the case of electroless plating, also slows or increases solution flow to areas of the plating surface and thus lowers or increases plating thickness and rates. The shielding or baffling also slows/isolates solution flow to the plating surface and thus lowers or raises plating thickness/rates. This causes more plating uniformity in panel or pattern plating equipment.

Further benefits and advantages of the invention will become apparent from a consideration of the following detailed description, given with reference to the accompanying drawings, which specify and show preferred embodiments of the invention.

#### Brief Description Of The Drawings

Figure 1 diagrammatically illustrates a plating apparatus embodying the electrolytic plating version of this invention.

Figures 2 and 3 are diagrammatic side views of portions of the plating apparatus of Figure 1, particularly showing the selective shield/material flow assembly of the apparatus.

Figure 4 is a front view of one of the selective shield/material flow assembly.

Figure 5 is a top view cutaway of a selective shield/material flow assembly having two selective shield material flow mechanisms. The selective shield/material flow assembly is placed between a workpiece and a flow source of fresh plating solution such as a nozzle or sperger. All are immersed in the electroless plating solution bath.

Figure 6 illustrates an operation of this invention.

Figure 7 and 8 are top and side views, respectively, of an electroless plating apparatus; an electroless version of this invention.

#### Detailed Description Of The Preferred Embodiments

Figure 1 illustrates electroplating apparatus 10 generally comprising anode 12, cathode 14, and selective shield/material flow assembly 16. Figure 1 also shows receptacle 20, electroplating solution 22, workpiece 24, selective shield/material flow assembly control 26, and selective shield/material flow assembly support 30. With reference to Figures 1-4, selective shield/material flow assembly 16 preferably comprises first and second individual selective shield/material flow mechanism 32 and 34, and connecting means 36 such as a series of connecting links. Each selective shield/material flow mechanism 32, 34, in

turn, includes a support member or frame 40 and a series of slats 42 as shown in Figure 4.

Returning to Figure 1, receptacle 20 holds the  
5 electroplating solution 22, which contains the ions of the metal or alloy to be deposited on the workpiece 24. Any suitable receptacle and electroplating solution may be used in the practice of this invention. Preferably, the  
10 receptacle is formed of an electrically insulating and corrosion-resistant material such as plastic. Also, by way of example, solution 22 may be a copper sulfate solution, commonly referred to as "acid copper."

15 Anode 12 and cathode 14 are both immersed in solution 22, and workpiece 24 is mounted on the cathode. In use, the anode is connected to the positive side of a direct current source, and the cathode is connected to the negative side of the current source. An electric current flows from the  
20 anode to the cathode, via solution 22, and as a result, ions in solution are attracted to and become attached to workpiece 24.

25 In this process, the thickness of the film formed on the workpiece is a function of the current density, which in turn is a function of the current distribution between the anode and the cathode.

Selective shield/material flow assembly 16 is provided to adjust controllably the current density, during the electroplating process, in order to improve the uniformity of the thickness of the formed film. More specifically, selective shield/material flow assembly 16 forms a multitude of openings, and the sizes of these openings can be adjusted, during the electroplating process, for selectively and controllably adjusting the amount of electric flux passing through the selective shield/material flow assembly and, thus, the distribution of the electroplating material across the workpiece.

As mentioned above, the preferred embodiment of selective shield/material flow assembly 16 shown in the drawings comprises first and second individual selective shield/material flow mechanism 32 and 34, and connecting means 36 such as links. First selective shield/material flow mechanism 32 forms a first series of openings 46, second selective shield/material flow mechanism 34 forms a second series of openings 48, and those openings, in combination, form the adjustable openings 46 and 48, as shown in Figures 2, 3, 4 and 5, of selective shield/material flow assembly 16. Links 36 connect shield/material flow mechanisms 32 and 34 together for limited movement relative to each other; and, as illustrated by Figures 2 and 3, selective shield/material flow mechanisms 32 and 34 are moved relative to each other to change the sizes of through

openings 46 and 48 of selective shield/material flow assembly 16.

5 Preferably, the individual selective shield/material flow mechanisms 32 and 34 are substantially identical, and thus only one will be described in detail. With particular reference to Figure 4, which shows selective shield/material flow mechanism 32, this selective shield/material flow mechanism comprises frame or support member 40 and a series  
10 of slats 42. Slats 42 are supported by the support member 40 and extend thereacross, and the slats are positioned so as to form openings 46. As shown in Figure 4, slats 42 slant across support member 40, although the slats may be positioned in other orientations.

15 While selective shield material flow (SSMF) assembly is shown with two selective shield material flow mechanisms, use of only one selective shield material flow mechanism is possible. Similarly, three or more SSMF mechanisms having 3  
20 or more sets of slats set at various angles relative to each other to form specific shaped openings as needed.

Support member 40 and slats 42 may be made of any suitable non-conductive material or materials, and the slats may be  
25 supported by the support members in any suitable manner. For example, the slats may be adjustably or slidably mounted on the support member, or the slats may be detachably connected to the support member.



In Figure 1 selective shield/material flow assembly control 26 is connected to selective shield/material flow assembly 16 for adjusting the sizes of openings 46 and 48 during the electroplating process. Preferably, this is done by moving  
5 selective shield/material flow mechanisms 32 and 34 relative to each other, and any suitable control may be used for this purpose.

Selective shield/material flow assembly support 30 is  
10 provided for supporting the selective shield/material flow assembly 16 for movement toward and away from at least one of the anode 12 and the cathode 14. Preferably, support 30 supports the selective shield/material flow assembly 16 for movement along three mutually orthogonal axes relative to  
15 both the anode and the cathode. As will be understood by those of ordinary skill in the art, any suitable support may be used in apparatus 10. In addition, the relative movement of the individual SSMF mechanisms can be a radial movement.

The present invention may be embodied in many different specific ways. For example, it may be noted that the  
20 present invention may be embodied in an apparatus in which the ions to be deposited on the workpiece come from the anode itself. In addition, in general, the apparatus can be  
25 used with electrolytic plating as well as electroless plating. It also has applications in areas other than plating such as air and fluid flow control, selective

cooling and drying of a surface, selective etching, photo circuitization, heating, and material flow.

5 This invention may also be used with many types of workpieces. For instance, as describe above, the workpiece may be a printed circuit board or panel, or a semiconductor chip. The present invention may also be practiced with other types of workpieces, for example, to apply a decorative coating to a substrate or surface.

10 With the preferred embodiment of the invention, and with particular reference to Figure 6, assembly 16 may be used to selectively isolate an area of a panel 24 from plating by use of individual adjustable selective shield/material flow mechanisms 32 and 34. The selective shield/material flow  
15 mechanism can be adjusted selectively on one, two or multi-axes. The shielding or baffling also slows/raises solution flow to the plating surface and thus, lowers/raises plating thickness/rates. This causes more plating uniformity in  
20 panel or pattern plating equipment. This would be beneficial in surface mounting applications and chip carriers. This assembly 16 can be used in either static or dynamic plating machines. It may be used to reduce plating costs by reducing total average/mean thicknesses on a panel  
25 as in sacrificial thieving like panel borders or features to be eliminated later.

The assembly 16 also saves the most dollars in a precious metal plating system. This assembly may be used to control plating thicknesses from the source (anode), rather than from the destination (panel), as in thieving. The mechanism could be sequentially operated to give varying degrees of opening/baffling in a dynamic plating system. This benefits the first and last panel entering/exiting a plating cell. The selective shield material flow assembly can be set up to move with a part or the selective shield material flow assembly can be held stationary relative to the part. In either case the openings of the selective shield material flow mechanism can be adjusted dynamically. The assembly allows plating to be performed at higher currents due to better distribution, thereby increasing production rates.

Figures 7 and 8 illustrate electroless apparatus generally comprising solution agitation spargers, workpiece(24), and selective shield material flow assemblies 16. Assembly 16 preferably comprises first and second individual selective shield/material flow mechanisms 32 and 34. Figure 8 also shows receptacle 20, electroless plating solution 51, workpiece(s) 24, selective shield material flow assembly control 26, and selective shield/material flow assembly supports 30. The selective shield material flow assembly essentially, in this case, selectively increases/decreases solution flow to the workpiece(s) which in turn increases/decreases plating thickness.

While the embodiments have shown methods and apparatus to perform selective electroplating or electroless plating, those skilled in the art will recognize that applications in areas other than plating are possible such as air flow control, drying and cooling, selective etching, photo circuitization and processing, heating control, e.g. infrared, and material flow e.g. spray coating, resist apply etc.

While it is apparent that the invention herein disclosed is well calculated to fulfill the objects previously stated, it will be appreciated that numerous modifications and embodiments may be devised by those skilled in the art, and it is intended that the appended claims cover all such modifications and embodiments as fall within the true spirit and scope of the present invention.